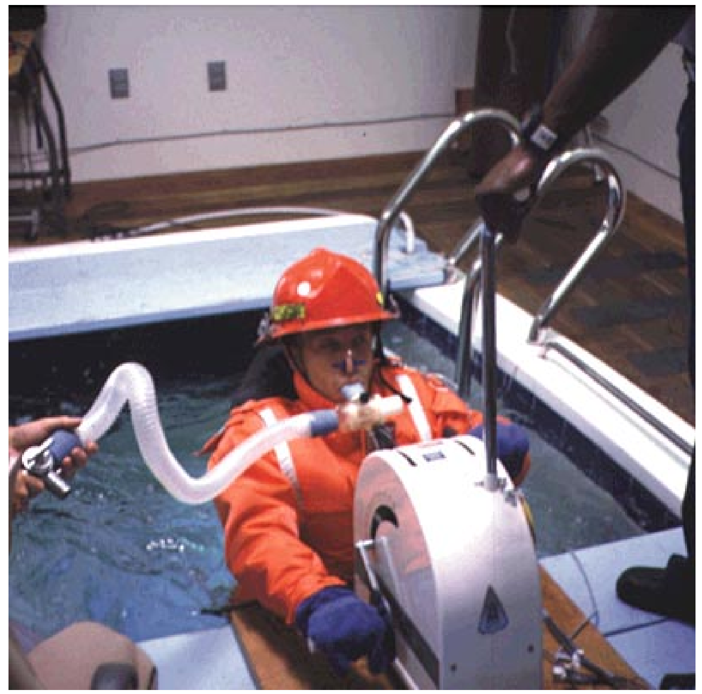
NHRC's Environmental Physiologists Evaluate Anti-Exposure Suits for Use During Shipboard Flooding Operations

Shipboard flooding as a result of mechanical failures, mismanagement of ballast, or breaches of the ship's hull often requires damage control personnel to work in cold ocean water. One of the most serious hazards of cold-water exposure is hypothermia caused by loss of body heat. Because the thermal conductivity of water is 20 to 25 times that of air, cold water quickly absorbs most of the heat which reaches the skin and poses a serious hazard for damage control personnel.

Naval personnel normally perform damage control for shipboard flooding operations dressed in dungarees or engineering coveralls. However, these garments have a minimal insulation capacity and do not provide adequate protection for cold-water exposure. Therefore, Dr. Don Hagan and Lt. Barry Cohen are working with the Personal Protection Division of the Naval Sea Systems Command to identify and evaluate a number of anti-exposure suit concept-designs for possible use by damage control personnel.

There are two basic types of anti-exposure suit designs which prolong staytime in cold air or ocean waters. These are called "wet" suits and "dry" suits. "Wet" suits usually cover the whole body and allow cold water to seep up the legs and down the arms to eventually cover the entire body surface. Protection from the cold is provided when this water layer between the skin and the inside of the suit is warmed sufficiently to reduce convection heat loss from the skin. On the other hand, "dry" suits prevent water from making direct contact with the skin, thus protection is greater because the air layer between the skin and suit serves as another barrier to heat loss.

In an initial set of studies supported by the Office of Naval Research, NHRC researchers evaluated two "wet" suits and one "dry" suit which were already in the Navy supply system but were not designed for damage control operations. These studies indicated that the "dry" suit, which was the CWU-62P anti-exposure coverall worn by Navy pilots, afforded the best protection, but was difficult to don and costly to manufacture. Subsequent tests evaluated three "dry" suits in a realistic flooding problem in which subjects performed



a pipe patching task while they were progressively immersed in cold water. In these tests, a British-made whole-body suit manufactured by MultiFabs Survival, Inc. provided the best overall protection against decreases in body temperature; however, a suit developed by the Naval Clothing and Textile Research Facility was nearly as effective and proved to be more durable under simulated operational conditions. Additional findings from laboratory and field studies also revealed a need to identify pliable waterproof work gloves to keep the fingers and hands dry and warm to maintain dexterity and patching effectiveness. These preliminary findings will aid in the future development of a cost effective, easily donned, anti-exposure "dry" suit designed specifically for shipboard flooding repair operations.

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Naval Health Research Center *San Diego, CA*

NHRC UPDATE

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NHRC Scientists Develop Breakthrough Alertness Monitoring Technology

The Office of Naval Research is supporting an exciting, high tech research program at NHRC to develop a capability to monitor alertness among Navy personnel in critical positions or situations. At least five trends make alertness an increasingly important issue for the future of the Navy and Marine Corps. First, the number of workers, both military and civilian, whose positions are staffed around the clock is steadily increasing. The Office of Management and Budget recently pointed out that the U.S. Navy is the world's largest employer of shift work personnel and urged the Navy to increase its attention to alertness and fatigue issues. Second, there is increasing pressure to radically reduce staffing in all positions, including ship crews. The current Navy Smart Ship project is attempting to reduce crew staffing by at least half through increased automation and system integration.

This may leave many key work stations under the watchful eyes of solitary operators without close supervision or an available relief.

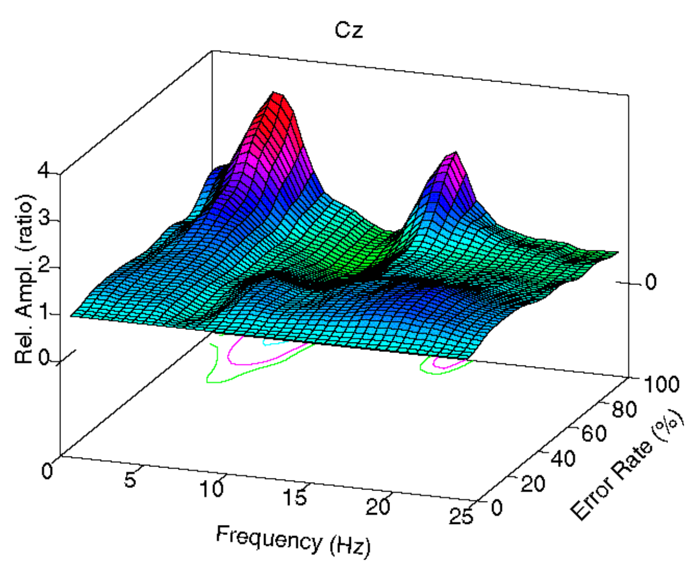
Ever-increasing automation poses a third challenge to maintaining vigilance and alertness. While computerized information systems can collect and display more and more detailed information, these systems may frequently leave their operators with little to do but monitor the streams of information they provide. Meanwhile, the ability of operators to maintain alertness and vigilance under such conditions has not increased and is bound by definite psychophysiological limits.

A fourth trend contributing to the growing importance of alertness in overall military performance is the increasing need for and frequency of global travel, often leading to jet lag or "desynchronosis" in which body rhythms and work schedule become out of sync with one another. Alertness problems occur most often under "contra-circadian" conditions, when our natural body clocks make us inclined to sleep while our work schedule, new time zone, or unforeseen events require us to work. Finally, modern warfare doctrine relies heavily on night operations, further increasing the "circadian stress" on front line fighters and their commanders during training and combat missions.

Research at NHRC has shown that precise information about an operator's current state of alertness is available in the small fluctuating electrical currents produced by the brain. These "electroencephalographic" or EEG signals, can be noninvasively recorded from the scalp, and change in size, location, and frequency as alertness diminishes. In the early phases of this work, Dr. Scott Makeig and colleagues at NHRC began studying the EEG of subjects who were attempting to press a response button whenever they heard a weak target sound during boring half-hour sessions conducted in a small, dark, sound-attenuated chamber.

Under these conditions, it was particularly difficult for subjects to stay alert and a wide range of performance changes resulted. Very few of the subjects were able to respond to every target. Instead, in many sessions the subject experienced "waves" of drowsiness lasting four minutes or longer in which they could respond only intermittently or not at all. After such a session, the subject would typically remember struggling to stay awake but would often severely underestimate the number of targets they had missed. Further research by Dr. Makeig and his colleagues, published last year in the journal *Cognitive Brain Research*, showed that the periods of intermittent responding during drowsiness have a definite time pattern which in most subjects consists of a series of 15-20 second dips into unawareness, much like listeners who find themselves "nodding off" during a boring lecture in a dark room or while reading an article such as this.

In 1993, Dr. Makeig and Mark Inlow published a paper in a leading EEG journal showing that these waves of drowsiness are accompanied by very specific changes in EEG patterns, and that these changes can be used to estimate changes in a subject's vigilance



3-D EEG plot to predict vigilance performance

performance. Further research established that while these changes vary somewhat from subject to subject, within subjects they are invariant and can be detected on-line in near real time. Working with Drs. Terrence Sejnowski and Tzyy-Ping Jung at Salk Institute, Dr. Makeig has developed a neural network algorithm for real-time alertness monitoring based on EEG data collected from four to five points on the scalp. This original algorithm provided a capability to monitor an individual's alertness and thereby predict his or her errors in a vigilance task. The still-greater accuracy of an advanced version of this algorithm has recently been demonstrated in a paper published by Dr. Makeig and colleagues in the *IEEE Transactions on Biomedical Signal Processing*. Results of this and related research are available on the world wide web (http://labhsp.nhrc.navy.mil/).

Dr. Makeig's research advances work done first at NHRC in the 1960's by former NHRC Scientific Director Dr. Laverne Johnson and associates, who noted the potential for real-time alertness monitoring based on EEG, but lacked the modern computer and neural network technology necessary to create a working system. Currently, Dr. Makeig is collaborating with LCDR Karl Van Orden of NHRC and researchers at Salk Institute, the University of California, San Diego, and NRaD on parallel streams of applied and basic research in operator state assessment based on EEG and eye tracking information. They are hoping to soon test a portable version of an EEG-based system to demonstrate its feasibility in monitoring alertness in an advanced command and control work station and gravity-induced loss of consciousness (GLOC) in Navy

and Marine Corps jet pilots. This operator status technology will provide the capability to more efficiently distribute the workload between the operator and the machine and marks a significant advance in human-system interface.

The NHRC research team, in collaboration with researchers at the University of Pennsylvania, is also assisting the National Highway Traffic Safety Administration in monitoring the alertness of truck drivers and developing appropriate drowsiness countermeasures during night driving. These tests are expected to involve prototypes of new "dry" electrode chips that can be worn comfortably by operators under a baseball cap or earphone head band without special skin preparation.

In the future, related psychophysiological monitoring methods could be used to detect when an operator fails to show a brain response to an important warning signal, and could increase the efficiency of computer-based training. With LCDR Neri of the NASA Ames fatigue research program, Dr. Makeig has proposed that future Navy and Marine Corps commanders have available an integrated alertness and fatigue management system to help them maintain the readiness-for-duty of their personnel under high circadian-stress conditions. Such a system might combine noninvasive crew rest monitoring and intelligent work/rest scheduling software with on-line cognitive assessment of operators at key work stations.

Naval Health Research Center

NHRC's Operations Research Division Streamlines Forward Medical Supplies for the Marine Corps

Having the right amount and type of medical supplies and equipment is essential for medical readiness. While insufficient medical materiel may result in manpower losses, attempts to move excessive quantities of supplies must be avoided

because scarce fiscal resources and transportation assets are diverted. The Commandant of the Marine Corps requested that NHRC review the Authorized Medical and Dental Allowance Lists (AMAL/ADALs) so that they accurately reflect changes in Marine Corps doctrine and policy as well as the anticipated reduction in casualty rates. Mike Galarneau and his colleagues Dr. Paula Konoske, Kevin Mahoney, and Kristee Emens-Hesslink are currently reviewing the medical supply and equipment lists for the Marine Corps' far forward medical treatment facilities.

Working closely with Marine Corps medical professionals, Mr. Galarneau linked the Echelon I and II medical tasks required to treat patients with specific patient condition codes established by the defense medical standardization board and compiled lists of the supplies and equipment required to perform each task. More than 85 subject matter experts from the 1st, 2nd, and 4th Medical Battalions, the 1st and 2nd Force Service Support Groups (FSSG), and the Naval Hospitals Camp Pendleton and Camp Lejeune reviewed treatment briefs, tasks, supplies, and equipment and determined their usefulness for Marine Corps Echelons I and II. The result of this work is a model of Echelon I and II supply stream that establishes a clinical requirement for each item used to support forward medical care.

AMALs containing the Echelon II lab and x-ray supplies and equipment were evaluated first. Studies showed that substantial reductions could be made in the number of items required, weight, and cube of the proposed AMALs when compared to the current Marine Corps AMALs. For example, 34 items in the proposed laboratory equipment AMAL could be eliminated with a corresponding 28% reduction in weight and 10% reduction in space, while in the proposed x-ray equipment AMAL there was a 14% weight savings and a net space savings of 4%. By establishing the clinical requirement for each item pushed forward, the NHRC model was able to reduce the logistical burden carried by Marine Corps units. This approach also produces an audit trail for each item because only items that can be clinically related to a treatment task conducted in theater are considered for inclusion in the AMALs. The Marine Corps Combat Development Center has endorsed NHRC's review process and has recommended that the process be used for the evaluation of the remaining AMALs.

Currently, Battalion Aid Station and Echelon II Operating Room AMALs are being revised. A computer program that estimates supplies and equipment requirements based on a given patient stream distribution has been designed and is under development. This will allow the current configuration to be revised using information such as the type of conflict anticipated, the expected duration, and changes in medical doctrine. Additional efforts are underway to use this methodology to evaluate the AMAL/ADALs of shipboard medical departments.